

# Mean Expiratory Diameter of the Inferior Vena Cava among Males and Females with CCF

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Ultrasonic; IVC Diameter; gender; cutoff values

## 1. Abstract

**1.1. Background:** Dilatation of the inferior vena cava (IVC) is used as the ultrasonic diagnostic feature in patients suspected of congestive heart failure. The IVC diameter has been reported to vary among the various body surface Area (BSA). Knowledge of these variations is useful in precision diagnoses of CHF by imaging scientists.

**1.2. Aim:** The study aimed to determine the ultrasonic mean expiratory diameter of the IVC among the various BMI and ABSI of males and females with CCF in Azare, Bauchi State-Nigeria.

**1.3. Methods:** One hundred and ninety nine subjects of both sexes diagnosed with Congestive Cardiac Failure were randomly classified into two (males and females). A structured questionnaire was used to rule out those that fell within the exclusion criteria. Their informed consent was sought for abdominal ultrasound scan. The probe was placed on the mid line of the body, half-way between the xiphoid process and the umbilicus with the marker on the probe directed towards the patient's head to obtain a longitudinal view of the IVC. The maximum IVC diameter was measured from the subcostal view using the electronic caliper of the scan machine during expiration on a B mode. The mean value of each group was obtained and analyzed statistically.

**1.4. Results:** It was observed that, the mean expiratory diameter of the IVC in males was (1.95± 0.048) cm and female (1.93 ± 0.068.) P value ≤ 0.05

**1.5. Conclusion:** In conclusion, the normal cutoff values for indicating a dilated IVC among the male and females in the populace has been established.

## 2. Introduction

Body Mass Index (BMI) and Waist Circumference (WC) are frequently used anthropometrics which are pointers of the degree of obesity estimated with height and weight and it is known to be tally with the risk of untimely death as well as diseases such as CCF [3].

However, both BMI and WC are short changed in medical practices [4]. In some Asian subjects, a study conducted among normal subjects in Karachi, the largest city in Pakistan, reveals that body mass index is a trusted variable to be given considered for avoiding false positive diagnosis of hepatomegaly, heart failure and portal hypertension on a sonogram [13]. In 2015, Taniguchi et al., reported that nutritional status and body surface area (BSA) have been reported to affect the dimension of the IVC and the intrahepatic vascular channels. In apparent terms, BMI and WC have their weaknesses in medical practices according to [4]. To underscore this inadequacy, a new metric was developed known as A Body Shape Index (ABSI).

Congestive cardiac failure (CCF) is a pathological condition caused by excessive accumulation of fluid within the heart principally due to ischemic and non ischemic conditions leading to deficient venous return and by extension, dilatation of the IVC [1].

Expansion of the inferior vena cava (IVC) is used as the ultrasonic diagnostic feature in persons suspected of congestive heart failure [11]. Several reports revealed that the IVC diameters are at variance with some body anthropometry [13]. However, no known study of this nature has been carried out on the body mass index (BMI). Knowledge of these differences is helpful in accurate diag-

noses of CHF by imaging scientists. Ultrasound scanning machine is useful in the evaluation of porto-systemic diseases like congestive cardiac failure [8]. In ultrasound examination, the anatomical structure of focus in diagnosing patients queried of heart failure is the inferior vena cava [11]. The use of ultrasound to accurately diagnose some critical pathological condition, such as porto systemic diseases like congestive cardiac failure often puzzles sonographers especially amateurs in the field and as such, they require great care, confidence among other factors in the use and manipulation of equipment apart from having a thorough knowledge and understanding of the anatomy of the inferior vena cava and it's

pathophysiology in order to make reasonably accurate diagnoses of congestive cardiac failure [14].

### 3. Materials and Methodology

The following materials were used for the study.

A stadiometer, Sono-crown ultrasound machine, 3.5MHZ of linear probe (transducer), gel, sono-printer and questionnaires

#### 3.1. Experimental Design

Participants were grouped into males and females as indicated in the table 1. The expiratory diameter of the inferior vena cava (MIVCED) in males and females were measured and the mean obtained.

**Table 1:** Methodology of research for male and female subjects

Healthy Subjects	Size	MIVCED (cm)
Males	80	1.93
Females	119	1.95

BMI: Body Mass Index, WC: Waist Circumference, ABSI: A Body Shape Index, M: Male, F: Female, MIVCED: Mean Inferior Vena Cava Expiratory Diameter.

#### 3.2. Sample Size

A survey was done using systemic random sampling technique and sample size was deduced using Yamane equation (2008 as indicated below:  $n_y = N / (1 + Ne^2)$ ). Where  $n_y$  is sample size, N is Population size and e is alpha level = 0.05 (If confidence interval is 95% or 0.95).

The population of Azare, Bauchi was estimated at 411,700 (National Population commission, 2020). Three hundred and ninety nine (399) was obtained as sample size and one hundred and ninety nine were diagnosed with CCF

#### 3.3. Study Location

Figure 1



**Figure 1:** Plate: I Insert in the Nigerian map is the geographical site of Azare, Bauchi, State.

Azare is located in Katagum, Bauchi, Nigeria. Its geographical coordinates are 11° 40' 42" North, 10° 11' 31" East (Maplandia.com)

#### 3.4. Sonographer/Ultrasound Unit

The ultrasound unit of Shifa'a Medical Centre, General Hospital and Federal Medical Centre all of Azare, Bauchi State were used for the study and the measurements were taken alongside with a certified and competent sonographer or a radiologist between April to December, 2020

#### 3.5. Inclusion criteria

1. All persons between the ages of 18 and 77 years and apparently healthy
2. All persons without CCF (normal or healthy subjects)

#### 3.6. Exclusion criteria

1. All persons below the age of 18 years and above 77 years
2. All persons with known hepatobiliary diseases like splenomegally, history of cholecystectomy or cardiac operation
3. All persons diagnosed of CCF that are either on treatment or not.
4. All pregnant women
5. All persons with obvious anatomical defect

#### 3.7. Patient and Methods

A randomly selective prospective study was carried out at Shifa'a

Medical Centre, General Hospital and Federal Medical Centre all in Azare, Bauchi State between March to December, 2020. One hundred (199) CCF patients comprising male and female subjects, aged between eighteen and seventy seven were randomly selected and grouped into two (Males and Females) with a membership of eighty (80) males and one hundred and nineteen (119) females. A structured questionnaire was used to help rule in those that fell within the inclusion criteria. They were subjected to abdomino-pelvic ultrasonography for assessment of the inferior vena cava (IVC) diameter in both inspirational and expiratory phases.

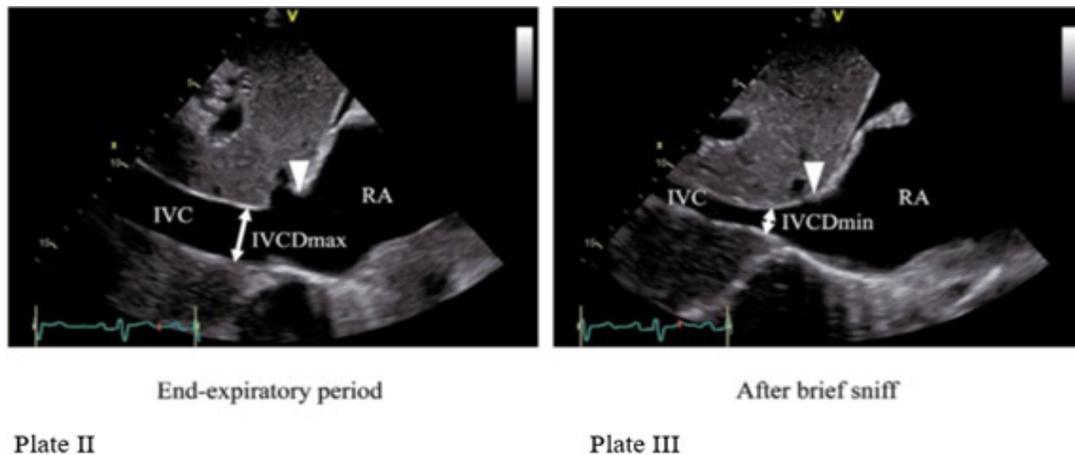
### 3.8. Experimental Procedures

Each subject was placed in a supine position and was encouraged to fast overnight in order to decrease the amount of bowel gas which may obscure the target structures. Male subjects were requested to put off their tops while female subjects were required to raise their tops, up to the sub costal margin. The abdomen preset was clicked on the ultrasound machine which is the recommended interphase for examining abdominal structures. A low frequency probe (3.5MHZ), that is, curvilinear transducer was used with an ultrasound gel applied on it.

### 3.9. Positioning and probe selection

The probe was placed on the mid line of the body, half-way between the xiphoid process and the umbilicus with the marker on the probe directed towards the patient's right side to obtain a transverse view. The IVC appears as an elliptical or "tear drop" structure on the right side of the patients mid line while the aorta appears on the left side. The IVC appears compressible under gentle pressure and not as pulsatile as the aorta. The probe was rotated longitudinally in clockwise direction to ninety degrees with the marker on the probe directed towards the head of the patient to obtain the longitudinal axis of the IVC. The long axis of the IVC was seen clearly below the xiphoid process with a branch of the hepatic vein draining into it. As shown below.

The maximum IVC diameter was measured from the subcostal view with the IVC displayed along its long axis in accordance with the method of [7, 14, 17]. The diameter was measured immediately caudal to the junction of the hepatic vein with the IVC and approximately 1–2 cm caudal to the junction of the IVC and the ostium of the right atrium as shown in plate II and III (Figure 2-4).



**Figure 2 and 3:** Plate II and III: Example of IVC ultrasound in the subcostal long axis view: Arrow head indicates the IVC-RA junction. IVC: Inferior Vena Cava; RA: right atrium (Kawata et al., 2017).



**Figure 4:** Plate IV: Image of the Inferior Vena Cava (Transverse view) old male obtained for inferior vena cava diameter emment from an ultrasonographic scan of the subject in Plate V Arrow indicates Anterior-Posterior (AP) diameter of the IVC. (Yusuf et al., 2022)

#### 4. Blood Pressure (BP) Measurements

The subject's blood pressures were obtained in accordance with W.H.O guidelines 2021. Those with blood pressure above 120/80 (mm HG) were considered as unhealthy subjects.

#### 5. Statistical Analysis

Data obtained were expressed as mean +/- (SEM) standard error of mean, student's 't' test was used to compare the mean difference between the groups and the level of significance was set at  $p \leq 0.05$ , and a 95% confidence interval was applied to the numerical variables which are normally distributed. Statistical analysis was carried out using Statistical Package for Social Science (SPSS)

Version 20.

Mean expiratory diameter of the Inferior Vena Cava among Males and Females with CCF.

An independent sample "t" test was conducted to examine the mean values of the ultrasonic expiratory diameter of the inferior vena cava in the males and their female counterparts in the subjects with CCF. The results in Table 2 showed that, the ultrasonic mean diameter of the inferior vena cava (IVC) in males and female are 1.95cm and 1.93cm respectively. Results in Table 2 and 3 show that no significant differences existed in the ultrasonic mean diameter of the males and females ( $P$  value = 0.713).

**Table 2:** Mean expiratory diameter of the inferior vena cava between the male and female subjects with CCF.

SUBJECT	IVC diameter (cm)	Std. Deviation	Std. Error
Males	1.95	0.213	0.0488
Females	1.93	0.30	0.068

$P$  value  $\leq 0.05$  is considered statistically significant.

**Table 3:** Level of significant differences in the mean expiratory diameter of the inferior vena cava between the males and females in CCF subjects

	Levene's Test for Equality of Variances	t-test for Equality of Means			
		F	Sig	t	df
IVC DIAMETRE	Equal variances assumed	1.48	0.231	0.112	36
	Equal variances not assumed			0.112	32

$p \leq 0.05$  (statistically significant), BMI= Body Mass Index, ABSI= A Body Shape Index, df = degree of freedom

#### 6. Discussion

The observed differences in the IVC diameters of males and female subjects were in consonance with the findings of Dambatta et al. (2016) who reported that the ultrasonic IVC diameter of males were wider than that of females. Jennifer et al. (2014) reported that women exhibited a higher circulating concentration of ANG-(1-7), a vasodilator compared with men, whereas values of ANG II were similar between groups (Jennifer et al., 2015). From the above literature, it is not clear why men still have wider IVC diameter than women. This study is also in line with the study of jianjun et al., 2015 who reported that in an univariate analysis, the maximum IVC diameter was positively correlated with sex with IVC diameter higher in males than in females. This means that, a number of variable risk factors ranging from sample size to effect of natural body hormones could affect the size of IVC.

#### 7. Conclusions

It can be concluded from this study that,

- (i) The ultrasonic mean expiratory diameter of the inferior vena cava (IVC) in male ( $1.95 \pm 0.048$ ) cm and female ( $1.93 \pm 0.068$ ) subjects along with their corresponding ABSI by BMI have been established
- (ii) No significant differences existed in the ultrasonic mean diameter of the males and females ( $P$  value = 0.713).

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